

# Magnetic Viruses via Nano-Capsid Templating

## Scientific Achievement

We used T7 bacteriophage (viruses) as templates for the fabrication of magnetic nanoparticle. This was achieved by first removing the DNA from the virus by alkaline treatment, which results in an empty virus capsid (ghost phage) with a 40-nm internal diameter. Subsequently iron oxide and cobalt nanoparticles have been grown within these capsid shells. Using enzyme linked immunosorbent assays we confirmed that the biochemical functionality is still maintained after replacing the DNA with magnetic materials. At the same time magnetic characterization indicated that the cobalt filled T7 bacteriophage is ferromagnetic at room temperature.

We furthermore demonstrated a novel biosensing concept using biologically functionalized magnetic nanoparticles. The frequency dependence of the magnetic susceptibility has been used to monitor the Brownian motion of free magnetic nanoparticles in aqueous solution, which have been coated (*i.e.* with avidin) for specific affinity to various molecules (*i.e.* biotin). The frequency shift in the response indicates a biochemical binding, and the magnitude of the shift is in accord with the changed hydrodynamic radius of the composite entity, as is supported by hydrodynamic theory. Thus a simple *ac* susceptibility measurement can be used for signal transduction.

## Significance

The fabrication of the magnetic virus is a paradigm shift for the preparation of functionalized magnetic nanoparticles. This work is currently in press [*J. Magn. Magn. Mater.*]. Traditionally functionalized magnetic nanoparticles are fabricated by first preparing the magnetic nanoparticles, *i.e.*, by chemical precipitation, and then afterwards suitable ligands were added to the surface to produce the desired functionality. For the magnetic viruses, the desired functionality is first created using phage display libraries, which easily allow selecting viruses with affinity reagents displayed on their capsid for virtually any potential target. Thus the functionality is established first, and then particles are made ferromagnetic subsequently. The magnetic virus can now be used as a building block to utilize biological self-organization for the creation of hierarchically self-assembled complex materials. Furthermore it enables diverse biomedical applications, of which we investigate biomagnetic sensing in particular. Part of this work has already been published [*Appl. Phys. Lett.*, **85** 2971 (2004)] and it has been presented several invited talks (Magnetics 2004, Workshop on Biomagnetism, and 49<sup>th</sup> Conference on Magnetism and Magnetic Materials).

## Performers

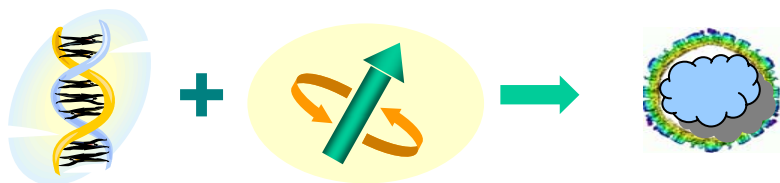
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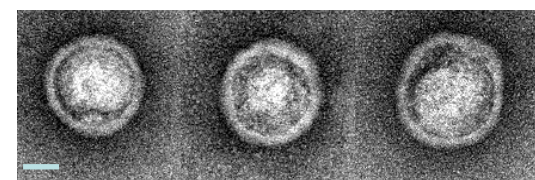
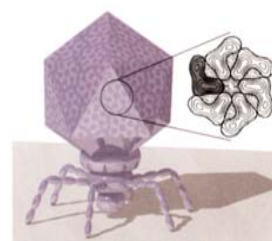
## Biomagnetism

Biology + Magnetism → Magnetic Virus



## Magnetic Virus

T7 Bacteriophage

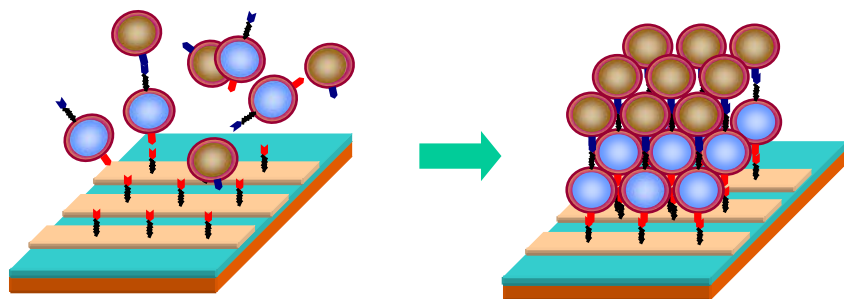


20 nm

Virus with Iron Oxide Inside

## Novel Magnetic Nanostructures Potential Biomedical Applications

Biologically Templated Hierarchical Self-Assembly



- Magnetic Separation and Purification
- Targeted Drug Delivery
- Hyperthermal Cancer Treatment
- Biosensing

